TOWARDS PREDICTING DEEP CONVECTION IN THE LABRADOR SEA

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LONG-TERM GOALS

This study contributes to a better understanding of the deep convective process in the ocean. In particular we are interested in the skill of prediction systems using real time data in combination with dynamical ocean models to forecast the oceanic state a few weeks up to a few month in advance. Finally, we would like to unravel the interaction of the deep convection with mesoscale eddies.

OBJECTIVES

- Inspect historical data from the Labrador Sea and make them available on the web.
- Develop a minimum prediction system to forecast the convective activity several weeks in advance.
- Assess the relative importance of one-dimensional mixing physics versus lateral effects due to mesoscale eddies or mean flows.

APPROACH

The first part of our effort builds on the analysis of historical data. This includes climatologies of oceanic and atmospheric data as well as individual ocean station data and results from pilot experiments during the winter 1994/95. We want to separate a typical mean seasonal cycle from interannual variability for the region. Once that is done we use the data sets do investigate heat, freshwater and buoyancy budgets for the subregions of interest. From those we should be able to estimate lateral flux divergences which then can be used as an additional forcing for the one dimensional prediction system.

The second task is to design a prediction system which can readily incorporate real-time temperature and salinity profiles from profiling ALACE floats (provided by R. Davis and B. Owens) and make use of climatological mean surface flux data. The simplest model will be based on one-dimensional mixing physics and can be used to predict the convective activity at the end of the winter season. This minimal prediction system will then be compared to the observations and also the evolution of dynamical ocean models (in collaboration with J. Marshall).

WORK COMPLETED

We have gathered and inspected most of the historical data and made them available on the web. The mean seasonal cycle and the interannual variability have been computed and we

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are now inspecting regional budgets. A first estimate of the lateral heat flux divergence was determined using data from a pilot mooring deployment and the findings are prepared for publication in collaboration with P. Rhines.

From November 1996 until early March of 1997 we have made experimental predictions for the expected maximum convective activity of the central Labrador Sea. Those predictions were used in combination with historical data to fine tune the winter cruise schedule. In particular the decision of where to deploy the convection floats was influenced by our predictions.

During the last few month we have set up a dynamical ocean model for the North Atlantic region and are currently preforming sensitivity studies using different parameter choices, initial conditions and surface forcing data sets.

RESULTS

One of the key questions in order to better understand and predict the deep convective activity in a basin such as the Labrador Sea is:

How strong is the lateral transfer of heat freshwater and hence buoyancy?

This quantity is important is two ways. Firstly, if there were no lateral flux of properties the newly ventilated deep water would not leave the region and hence would only insignificantly contribute to the ocean ventilation. Therefore it is directly related to the overall deep water formation rate of the basin. Secondly, the lateral transfer of heat and freshwater will influence the local stratification and thereby influence the vigor of deep convection for the next winter season. The inspection of surface heat flux data sets and annual time series of heat content in the central Labrador Sea yielded an annual mean lateral heat flux divergence which is equivalent to an annual mean heat loss of 50-100 W/m^2. The vertical structure of that heat flux is equally important and decays strongly with depth. About 50% of the lateral flux divergence was found to be in the upper 200 m of the water column. We are currently performing a similar analysis for the fresh water flux divergence.

The second important result was that it is feasible to perform real-time predictions of the expected deep convective activity. The first trial for the prediction system based on the simplest possible balance has proven to be useful. We made use of real-time temperature and salinity data from profiling ALACE floats with a delay of about one-two weeks. The predictions based on this simple system gave consistently a maximum depth of the deep convective activity of about 800 m which turned out to be close to the observed value during the winter cruise in March 1997. As an example figure 1 shows one of this maps where we also included a hand drawn diagnostic of where the convection might be deepest.

The first trials using a more complete three-dimensional dynamical model have shown that it is harder to overcome model shortcomings such as to much diffusion and to weak advection within the boundary currents. However, those simulations might still be the way to go once we have a better understanding of the fundamental problems.

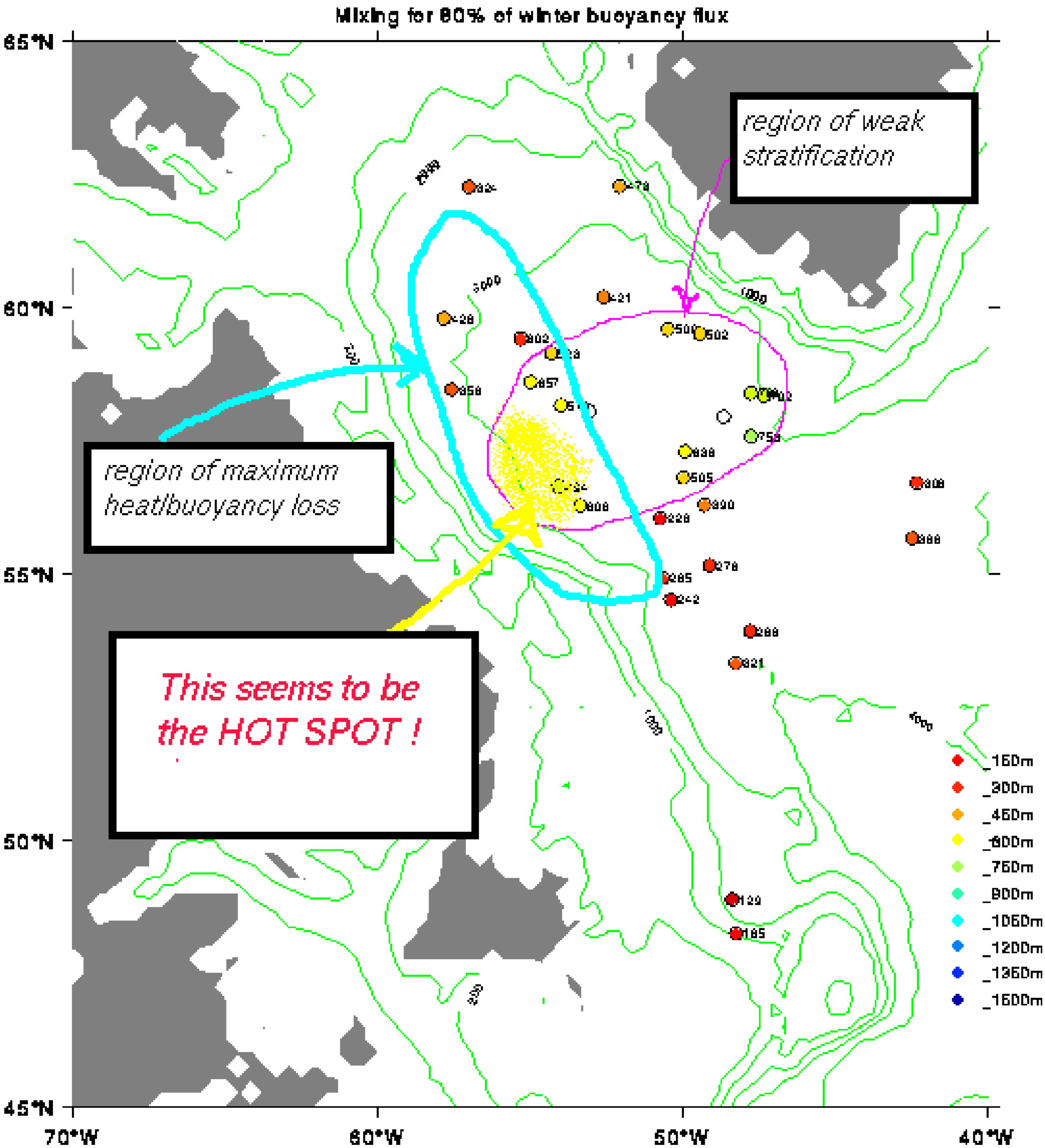

Figure 1: Prediction of the expected mixed layer depth using the PALACE float stratification (thanks to R. Davis) and a climatological forcing. Based on this information we pointed to a region where the chances for deep convective mixing were maximum.

IMPACT/APPLICATIONS

This study will help to identify potential problems of dynamical forecast systems in regions of deep mixing activity. It will also give an assessment of state of the art ocean circulation models in regions where deep convection is expected.

TRANSITIONS

We develop research mode systems which are not designed to be directly transferred to operational centers. However, the concept can readily be adopted and the identification of major shortcomings as well a potential solution should be beneficial for operational ocean forecast efforets.

RELATED PROJECTS

Our project is well connected to many other components of the Accelerated Research Initiative “Deep Convection”. We work with sea going projects to guide their observational strategies, disseminate information relevant to the group and also provide some generic information about the ARI on the web. We closely collaborate with the modelling effort at MIT (J. Marshall) and will compare their high resolution results to our coarse resolution simulations.We are providing objectively analyzed temperature and salinity fields as initial conditions for their simulations. A crucial part of our project depends on the real time PALACE data provided by R. Davis.

REFERENCES

Most of our work can be found on the web under
http://www.ldeo.columbia.edu/~visbeck/labsea